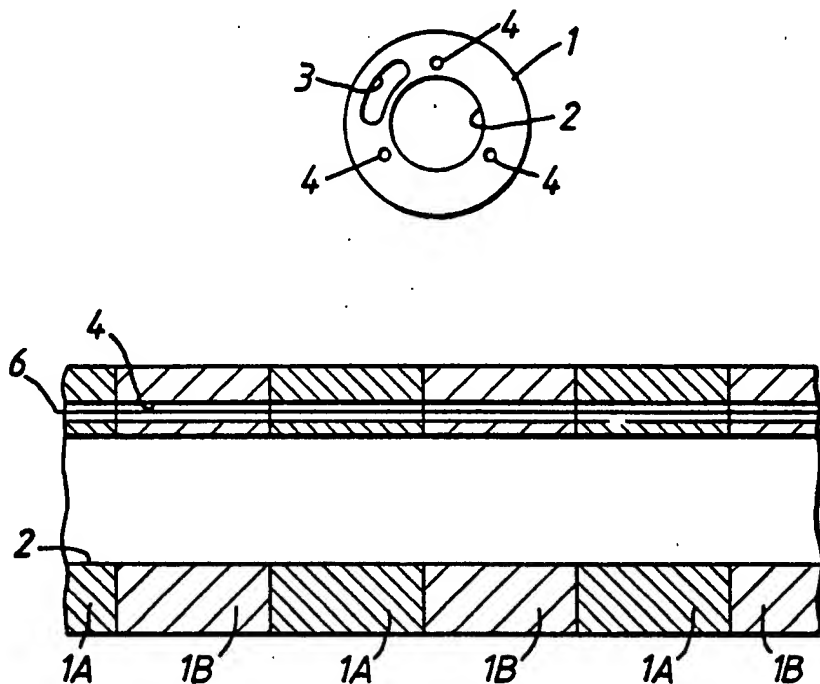


## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<b>(51) International Patent Classification<sup>4</sup> :</b> <b>A61M 25/00, G01N 24/02</b>	<b>A2</b>	<b>(11) International Publication Number:</b> <b>WO 87/04080</b> <b>(43) International Publication Date:</b> 16 July 1987 (16.07.87)
<b>(21) International Application Number:</b> PCT/GB87/00014 <b>(22) International Filing Date:</b> 13 January 1987 (13.01.87) <b>(31) Priority Application Number:</b> 8600665 <b>(32) Priority Date:</b> 13 January 1986 (13.01.86) <b>(33) Priority Country:</b> GB <b>(71)(72) Applicant and Inventor:</b> LONGMORE, Donald, Bernard [GB/GB]; 97 Chertsey Lane, Staines, Middlesex (GB). <b>(74) Agent:</b> SIMPSON, Ronald, Duncan, Innes; A.A. Thornton & Co., Northumberland House, 303-306 High Holborn, London WC1V 7LE (GB).		<b>(81) Designated States:</b> AT (European patent), BE (European patent), CH (European patent), DE (European patent), FR (European patent), GB (European patent), IT (European patent), JP, LU (European patent), NL (European patent), SE (European patent), US.  <b>Published</b> <i>Without international search report and to be republished upon receipt of that report.</i>

**(54) Title:** SURGICAL CATHETERS**(57) Abstract**

Surgical catheters (1) are composed of materials which are non-magnetic and opaque or translucent under Nuclear Magnetic Resonance examination, and preferably of segmented construction, with segments of highly opaque material (5) alternating with segments of less opaque material (6) to facilitate observation of the catheter by NMR image reconstruction.

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Surgical Catheters

This invention relates to operating catheters for use in surgical procedures.

Catheters in accordance with the invention are characterized in that they are composed of non-magnetic materials which are opaque or translucent under Nuclear Magnetic Resonance (NMR) examination. Suitable materials may be hydron, or strongly paramagnetic materials such as gadolinium. The catheters are preferably of axially segmented construction, having segments of highly opaque material alternating with segments of less opacity, so that the precise location of the catheter is readily apparent under NMR examination and visually at the distal end.

The catheters have, in each case, a main central lumen for the passage e.g. of optic fibres for laser surgery, or of drugs for perfusion into an organ or into a cancer, or of control elements for the manipulation of surgical instruments carried at the distal end of the catheter.

Additionally, further, small lumens may be provided through the length of the catheter wall, for the passage of guidance wires, or gas, or drugs.

The catheters are preferably coated, internally and externally, with thin layers of silicone rubber.

In each case, these catheters permit the conduct of

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many operations and treatments which would otherwise be carried out under X-ray. When operations are of long duration or require repetitions, the patient is subjected to undesirable high exposure to X-ray radiation. The present catheters make it possible to conduct various procedures under NMR examination, which is non-invasive and not subject to the risks attendant upon exposure to radiation.

Some catheters in accordance with the invention and attachments for use therewith will now be described by way of example, with reference to the accompanying drawings, in which:

Fig. 1 is a diagrammatic cross-section of a catheter for use in cancer treatment;

Fig. 2 is an axial section, drawn to a larger scale, of the catheter of Fig. 1;

Fig. 3 is a perspective sketch of a second form of catheter, for use in laser surgery;

Fig. 4 is a perspective sketch of a catheter fitted with a suturing device;

Fig. 5 is a front end view of a catheter fitted with a suturing device;

Figs. 6 and 7 are axial sections on the lines A',A' and A,B respectively, of Fig. 5; and

Fig. 8 is a front end view showing a suture needle in position.

The catheter 1 of Figs. 1 and 2 is composed of alternating annular segments 1A, 1B of materials which are highly opaque to NMR examination and less opaque, respectively. The catheter has thin coatings of silicone rubber on its external surface and the internal surface of its main, central lumen 2. For the treatment of cancers, the lumen is charged with a quantity of embolising material which can be selectively discharged through the distal end of the catheter by a plunger (not shown)

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of NMR opaque material operable from the proximal end of the catheter.

A secondary lumen 3 formed through the wall of the catheter is charged with sclerosing materials. Three  
5 equi-spaced fine lumens 4 also extend longitudinally through the catheter wall and form passages for high tensile guide wires 6. At the distal end, these wires are secured to the catheter wall, and at the proximal end they are coupled to a joystick or rollerball control  
10 which permits the wires to be selectively and individually tightened or relaxed so as to permit guidance of the distal end of the catheter.

In use of the catheter, embolising material can be selectively discharged into an artery supplying a  
15 tumour, or a vein draining it or both. The secondary lumen 3 may be used for the injection of sclerosing materials into the arterial system before embolisation.

Use of the catheter under NMR examination has the additional advantage that the efficacy of embolisation  
20 can be monitored while the treatment is under way by NMR examination of blood flow sequences.

In a modification the catheter may be of simple construction with just a main lumen, for use in the perfusion of tumour killing drugs which are too toxic  
25 to be administered systematically.

Fig. 3 illustrates a catheter specifically for use in laser treatment of coronary atheroma. The catheter is of generally similar construction to that of Figs. 1 and 2, but its main lumen carries a sheathed  
30 bundle of optic fibres for transmitting laser light to the site. The sheath 7 may incorporate additional fine lumens 8 for the perfusion of prostacyclin or other platelet controlling agents, and a dye for staining atheromous material to a colour which makes it sus-  
35 ceptible to laser light. These lumens may, of course,

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alternatively be incorporated through the wall of the catheter.

Further fine lumens corresponding to the lumens 4 of Fig. 1, are provided for controlling wires, as before, for the supply of pressurised gas to a small inflatable sac or sacs 9 carried near the distal end of the catheter. Preferably, these sacs are distributed about the circumference of the catheter. They are individually inflatable (or collapsible) so as to press against the artery wall and thereby permit fairly precise positioning and orientation of the distal end of the catheter and thus of the laser light emitted from it. The sacs may also be abruptly inflated together to disrupt an occlusion.

In a further group of modified catheters, adapted for surgical procedures such as suturing, boring, biopsy sampling and guiding pacemaker wires into position, the catheters are again of the same basic construction, but no lumens are provided for the passage of drugs or other agents to the site. The catheter again incorporates lumens for control wires and the central lumen is employed for the mechanical control elements to operate tool pieces mounted at the distal end of the catheter.

Fig. 4 illustrates such a catheter fitted with a suturing device. The central lumen houses a flexible, torque-transmitting control cable attached to a suture driver 11 of tubular form, having bayonet slots 12 for locating the cross tang 13 of a wire suture of helically spiralling form, the helix becoming progressively tighter in a direction away from its pointed leading end. The tang is engaged across the inner ends of the bayonet slots. The suture is applied by pressing it against the site to be stitched and then rotating it, by operation of the control cable, causing the pointed end to penetrate the septal wall (or other muscle or material to be stitched) and with continual rotation the suture is

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wound progressively into the muscle and concomitantly drawn out of the bayonet slot.

Instead of the suturing device described and illustrated, the same catheter can be fitted with other  
5 tool pieces specially adapted for boring, removal of samples for biopsy or the guidance of pacemaker wires.

The catheter shown in Figs. 5 to 8 is for stitching with a filamentary suture. In this case, the catheter is provided with a small central lumen to receive the  
10 suture filament 12 and two further lumens housing control cables 13. Coupled to the distal end of the catheter is a suturing device comprising a generally cup-shaped housing 14 having two through holes in its front wall in which are mounted respective grippers 16.  
15 The holes are angled away from each other, and they taper forwardly. The grippers 16 are of a springy material and each has a pair of jaws which are forced together when the gripper is pushed forwardly in its tapered hole. When partially retracted, the jaws spring  
20 apart again. The grippers are of generally circular cross-section and are keyed against rotation in their holes. At their rear ends, the grippers are releasably connected as by ball and socket joints 17 to their respective control cables 13.

25 Initially, and as shown as Fig. 8, the grippers are both closed against a suture needle 18 attached to the suture filament. The catheter is inserted through a blood vessel to the site to be repaired and suturing is effected by rotation of the head and alternate operation  
30 of the grippers to push and pull the needle through the muscle or other tissue to be stitched. The head may be rotatable by a control cable or it may be rotatable within a surrounding sheath extending substantially the full length of the catheter.

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CLAIMS:

1. A surgical catheter composed of a non-magnetic material (or materials) which is (or are) opaque or translucent under Nuclear Magnetic Resonance (NMR) examination.
2. A catheter according to claim 1, characterized in that the catheter is of axially segmented construction, having segments (1A) of highly opaque material alternating with segments (1B) of less opacity.
3. A catheter according to claim 1 or 2, having a central lumen, characterized in that further lumens (4) are provided through the length of the catheter wall.
4. A catheter according to claim 3, characterized in that a plurality of said further lumens (4) are distributed circumferentially about the catheter wall and that guidance wires (6) are housed in the said further lumens (4) and are secured to the wall of the catheter at its distal end and at the proximal end are coupled to a control mechanism for selective tensioning of the wires to facilitate radial guidance of the distal end of the catheter.
5. A catheter according to claim 3, characterized in that the said further lumens (4) form passages for the supply of pressurized fluid to selectively inflatable sacs (9) distributed about the exterior of the catheter wall at the distal end thereof.
6. A catheter according to any preceding claim, characterized in that the central lumen (2) of the catheter houses a bundle of optical fibres for the transmission of



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laser light to the distal end of the catheter.

7. A catheter according to any one of claims 1 to 5, characterized in that the catheter carries a rotatable suturing device (11;14,16) at its distal end.

8. A catheter according to claim 7, characterized in that the suturing device comprises a generally cup-shaped housing (14) and a pair of grippers (16) each having a pair of jaws projecting through the front wall of the housing and connected at their rear, inner ends to respective control elements by which the jaws of the grippers can be alternately opened and closed for manipulation of a curved suturing needle.

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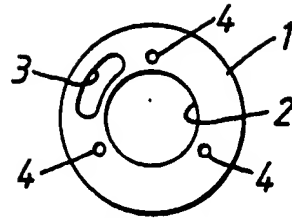


FIG. 1.

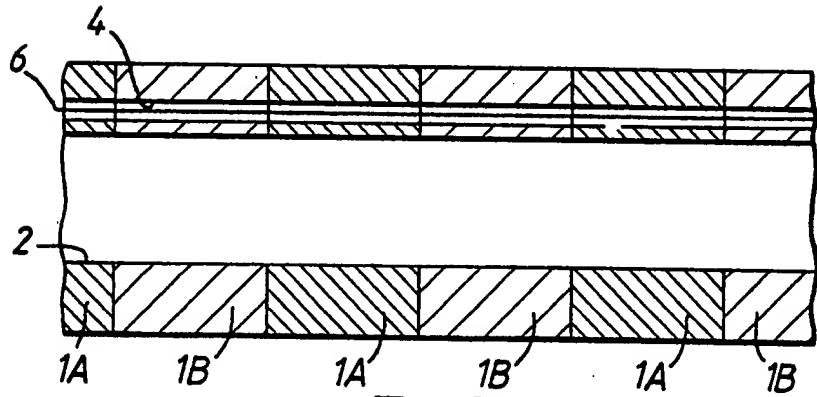


FIG. 2.

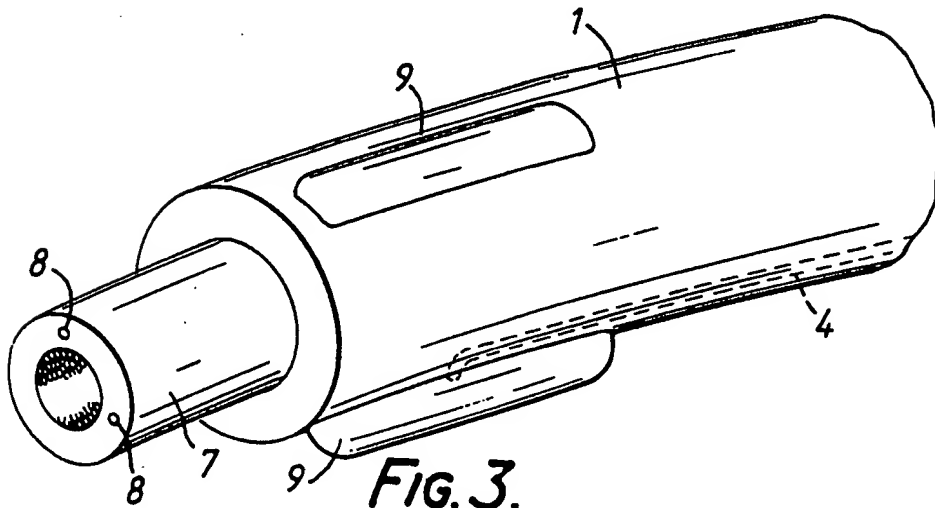


FIG. 3.

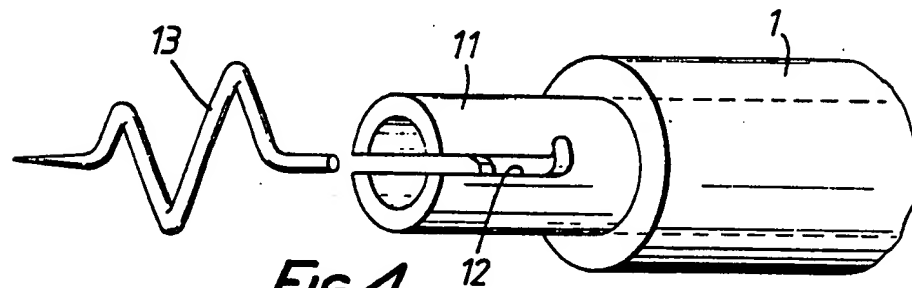


FIG. 4.

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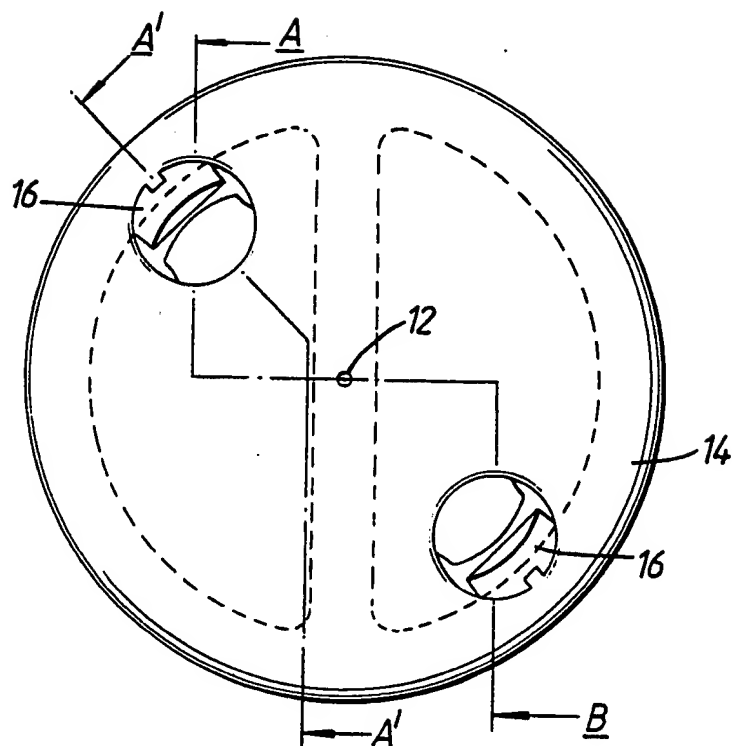


FIG. 5.

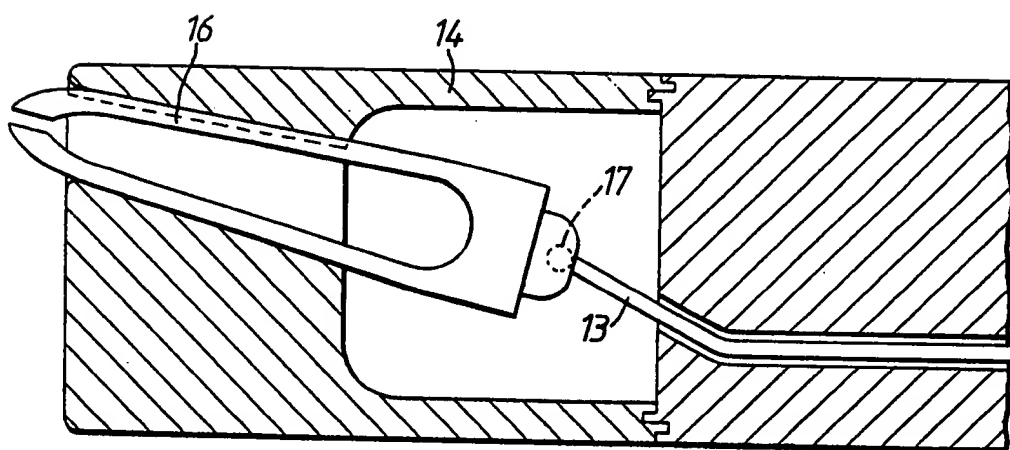


FIG. 6.

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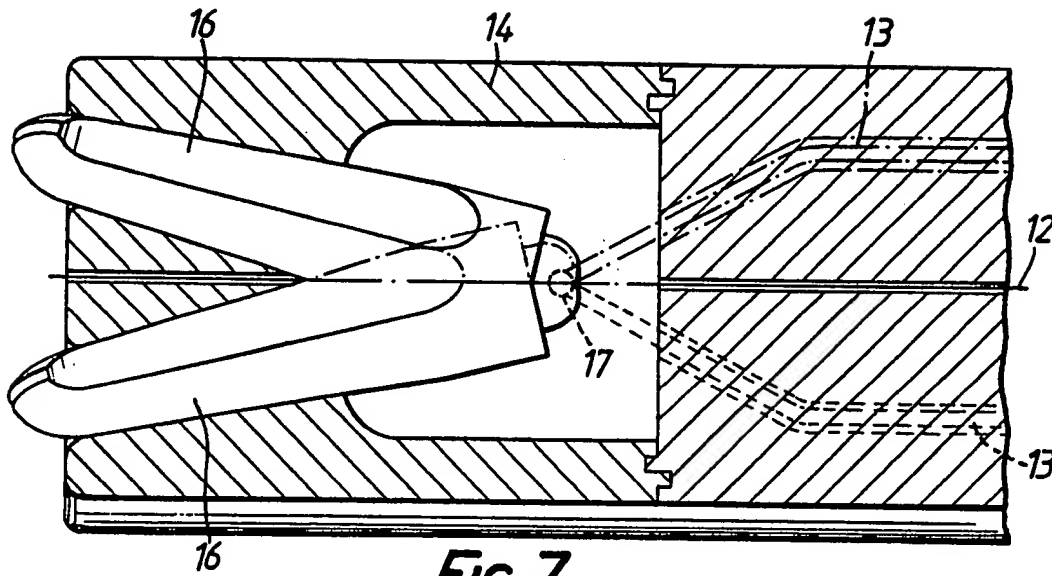


FIG. 7.

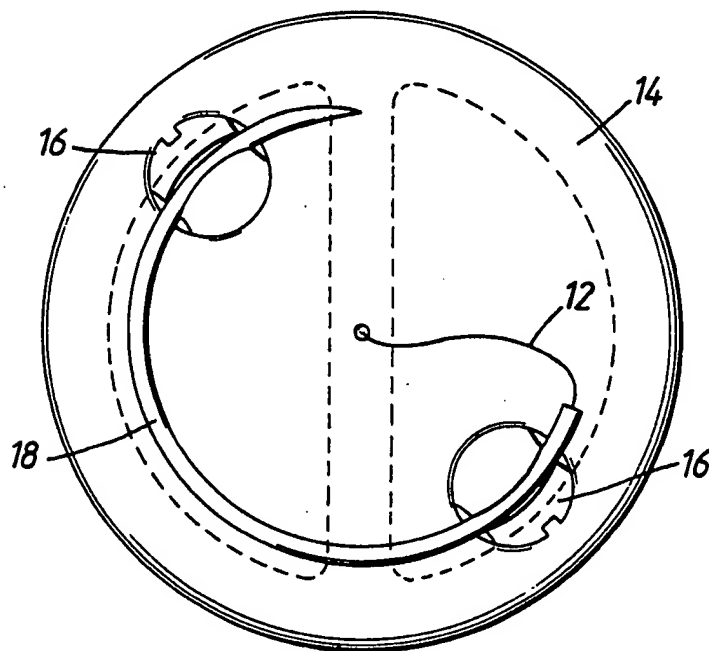
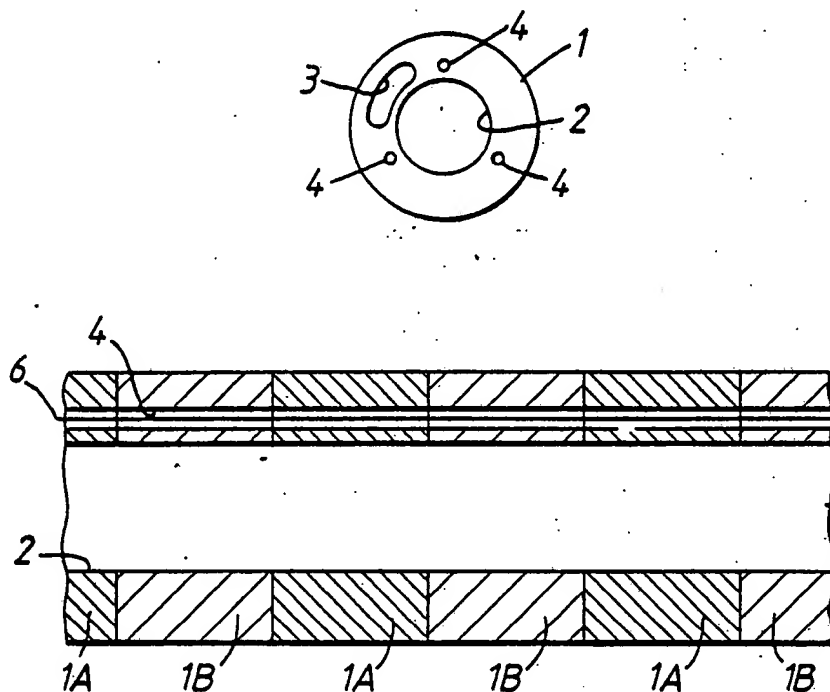


FIG. 8.

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<p>(51) International Patent Classification<sup>4</sup> : <b>A61M 25/00, G01N 24/02</b></p>	<p><b>A3</b></p>	<p>(11) International Publication Number: <b>WO 87/ 04080</b> (43) International Publication Date: <b>16 July 1987 (16.07.87)</b></p>
<p>(21) International Application Number: <b>PCT/GB87/00014</b> (22) International Filing Date: <b>13 January 1987 (13.01.87)</b> (31) Priority Application Number: <b>8600665</b> (32) Priority Date: <b>13 January 1986 (13.01.86)</b> (33) Priority Country: <b>GB</b> (71)(72) Applicant and Inventor: <b>LONGMORE, Donald, Bernard [GB/GB]; 97 Chertsey Lane, Staines, Middlesex (GB).</b> (74) Agent: <b>SIMPSON, Ronald, Duncan, Innes; A.A. Thornton &amp; Co., Northumberland House, 303-306 High Holborn, London WC1V 7LE (GB).</b></p>		<p>(81) Designated States: <b>AT (European patent), BE (European patent), CH (European patent), DE (European patent), FR (European patent), GB (European patent), IT (European patent), JP, LU (European patent), NL (European patent), SE (European patent), US.</b>  <b>Published</b> <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>  (88) Date of publication of the international search report: <b>13 August 1987 (13.08.87)</b></p>

(54) Title: **SURGICAL CATHETERS**



(57) Abstract

Surgical catheters (1) are composed of materials which are non-magnetic and opaque or translucent under Nuclear Magnetic Resonance examination, and preferably of segmented construction, with segments of highly opaque material (5) alternating with segments of less opaque material (6) to facilitate observation of the catheter by NMR image reconstruction.

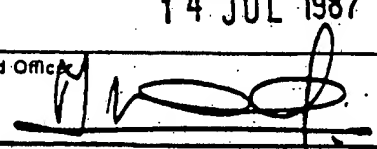
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# INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 87/00014

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (If several classification symbols apply, indicate all) <sup>6</sup> According to International Patent Classification (IPC) or to both National Classification and IPC IPC <sup>4</sup> : A 61 M 25/00; G 01 N 24/02		
<b>II. FIELDS SEARCHED</b>		
Minimum Documentation Searched <sup>7</sup>		
Classification System	Classification Symbols	
IPC <sup>4</sup>	A 61 M; A 61 B; G 01 N	
Documentation Searched other than Minimum Documentation to the extent that such Documents are included in the Fields Searched <sup>8</sup>		
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT <sup>9</sup></b>		
Category <sup>9</sup>	Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>
X	EP, A, 0165742 (VARIAN ASSOCIATES) 27 December 1985, see page 1, line 27 - page 2, line 20; claims 1,2	1,3,6
Y	--	2,4,5
Y	US, A, 3847157 (CAILLOUETTE et al.) 12 November 1974, see column 1, lines 46-61	2
Y	--	
Y	US, A, 3058473 (WHITEHEAD) 16 October 1962, see column 5, lines 34-73; claim 1; figures 6,12-14	4,5
P,X	--	
P,X	WO, A, 86/01093 (BERKE) 27 February 1986, see page 5, line 14 - page 6, line 23	1,3,4
A	--	
A	US, A, 3470876 (BARCHILON) 7 October 1969	
A	--	
A	DE, A, 2820239 (OLYMPUS OPTICAL) 16 November 1978 -----	
<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p><sup>10</sup> Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 45%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"A" document member of the same patent family</p> </div> </div>		
<b>IV. CERTIFICATION</b>		
Date of the Actual Completion of the International Search		Date of Mailing of this International Search Report
7th April 1987		14 JUL 1987
International Searching Authority		Signature of Authorized Officer
EUROPEAN PATENT OFFICE		M. VAN MOL 

## FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE <sup>1</sup>

This International search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers ..... because they relate to subject matter not required to be searched by this Authority, namely:
  
2. ☐ Claim numbers ..... because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
  
3. ☐ Claim numbers ..... because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI. ☒ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING <sup>2</sup>

This International Searching Authority found multiple inventions in this international application as follows:

- claims 1-6 : Surgical catheter opaque or translucent under NMR comprising guide wires, inflatable sacs and optical fibres
- claims 1,7,8: Surgical catheter carrying a rotatable suturing device

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.
2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:
3. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers: 1-6.
4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

## Remark on Protest

- ☐ The additional search fees were accompanied by applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.



This Annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 25/06/87

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A- 0165742	27/12/85	JP-A- 61013974 US-A- 4572198	22/01/86 25/02/86
US-A- 3847157	12/11/74	None	
US-A- 3058473		None	
WO-A- 8601093	27/02/86	EP-A- 0191828 JP-T- 62500048	27/08/86 08/01/87
US-A- 3470876	07/10/69	None	
DE-A- 2820239	16/11/78	JP-A- 53139390	05/12/78